Climate Change, Sea Level Rise and Ocean Acidification

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Global Climate is Really Changing

2012 Heat Wave

Top: In the US, the 2012 heat wave caused massive wildfires, 82 deaths, power outages and record drought.

Right: In China, they crowded pools to escape the heat (REUTERS/Stringer)

Permafrost is Melting
(and shorelines are retreating)

http://thesinkhole.org/2011/02/18/fairbanks-alaska-february-18th-2011/

http://www.epa.gov/climatechange/impacts-adaptation/alaska.html

http://planetparadigm.wordpress.com/2009/02/05/global-climate-change-forget-the-climate-models-wheres-the-real-evidence/

Glaciers are Melting

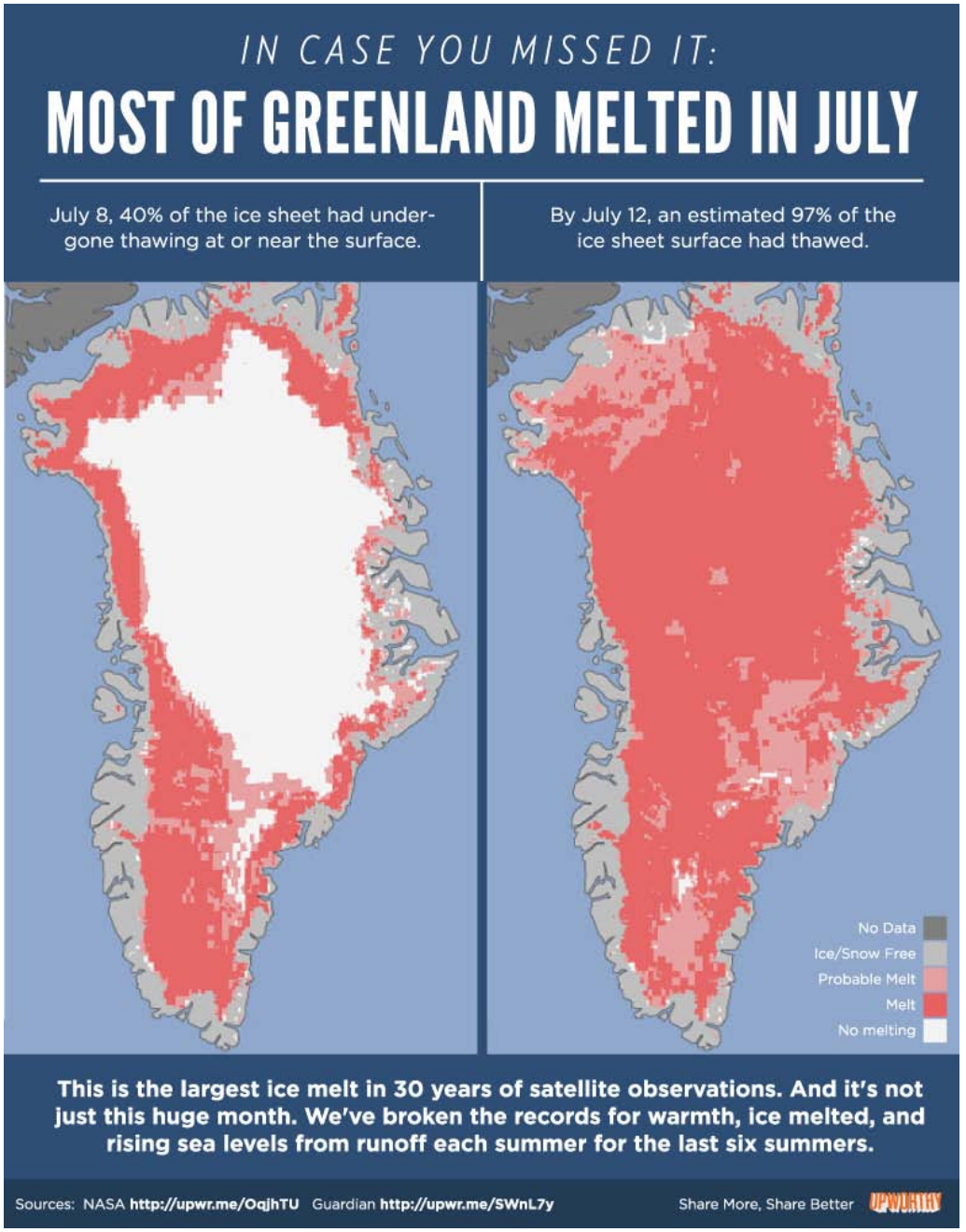
Muir Glacier (1976)

Muir Glacier (2003)

Photos: Bruce Molnia http://nsidc.org/data/glacier_photo/

July 8-12, 2012

Note: Refers to surface ice (not entire mass)



Images: http://www.nasa.gov/topics/earth/features/greenland-melt.html

Sea Levels are Rising

http://www.npr.org/2011/02/16/133650679/climate-change-and-faith-collide-in-kiribati

http://worldnews.nbcnews.com/_news/2012/03/09/10618829-as-sea-levels-rise-kiribati-eyes-6000-acres-in-fiji-as-new-home-for-103000-islanders

Climate ≠ Weather

Posted: 10:27 p.m. Sunday, Dec. 8, 2013

Cold snap continues to freeze Bay Area

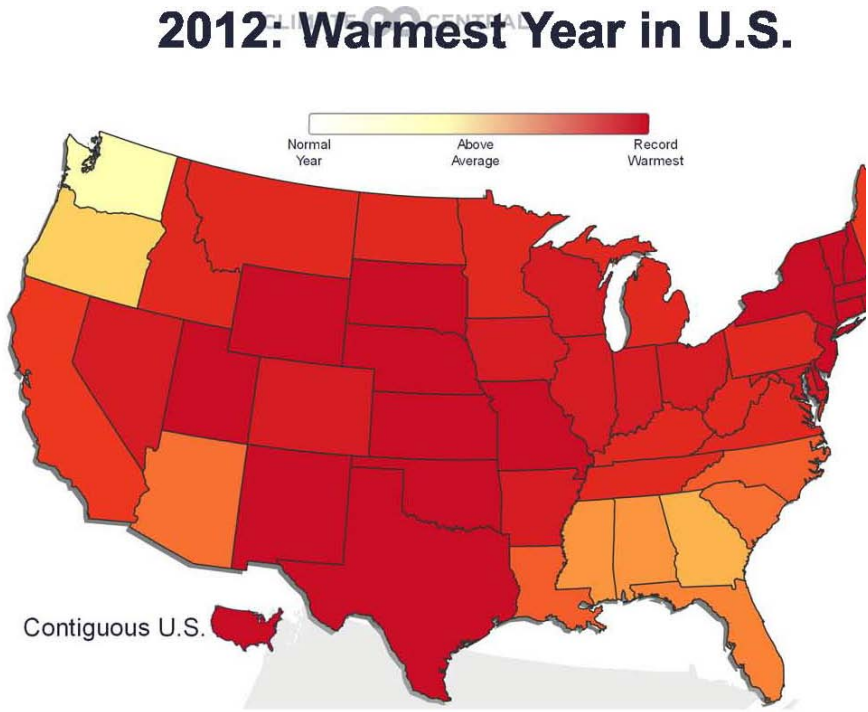
London Evening Standard

[published Nov 13, 2013]

UK weather: London set for cold snap as freezing temperatures head south

NOAA: 2012 Hottest & 2nd-Most Extreme Year On Record

Published: January 10th, 2013
By Andrew Freedman



NOAA/NCDC U.S. Climate at a Glance

Temperatures are Rising
2012: Warmest Year in the U.S.

based on 118 years of temperature records (since 1895)

http://www.climatecentral.org/news/noaa-2012-was-warmest-and-second-most-extreme-year-on-record-15436

More Extreme Weather Events

Typhoon Haiyan (Phillipines, Nov 2013)

Mark McGuire

Career home runs: 583

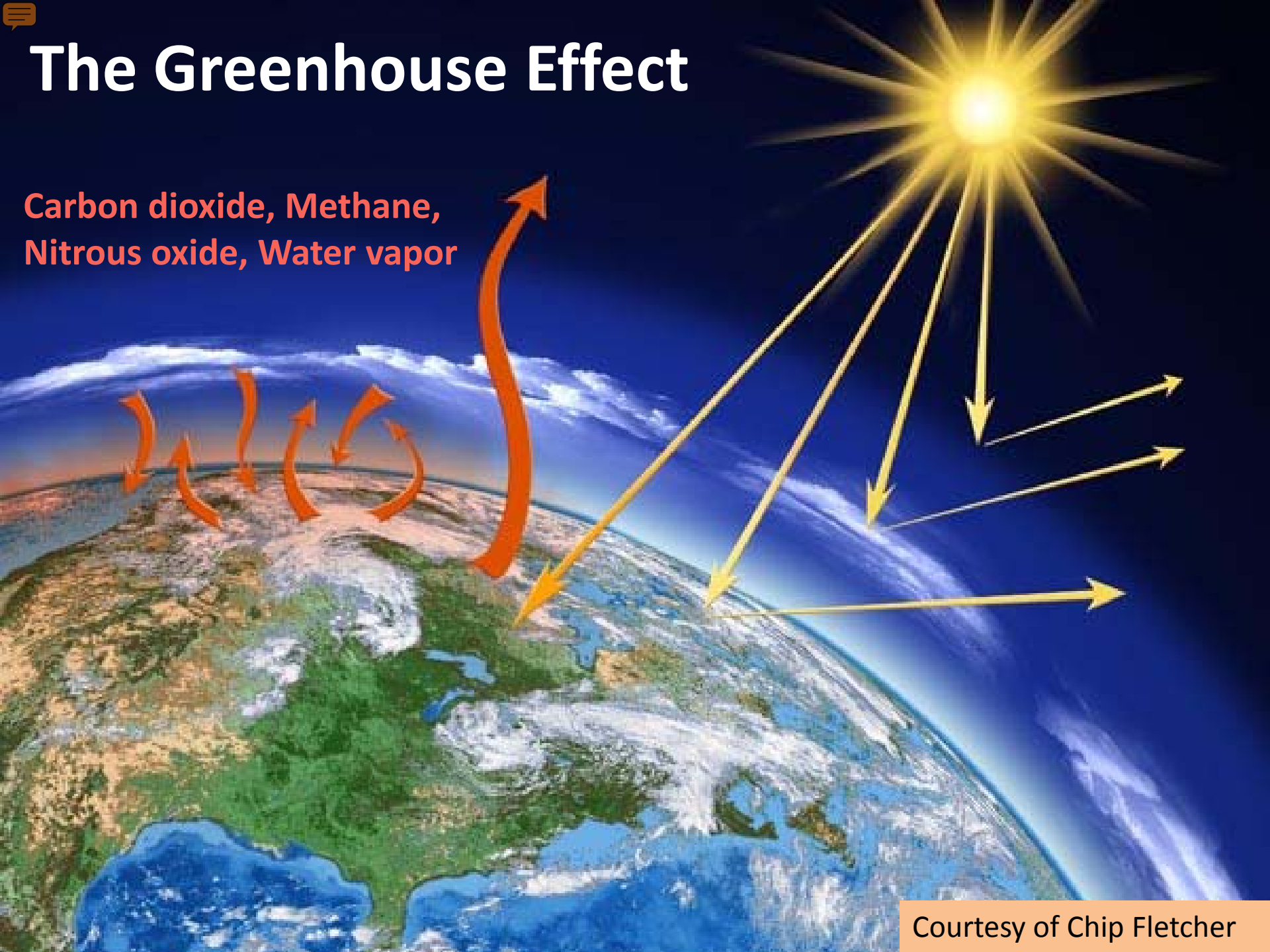
Season record (1998): 70

Lance Armstrong

Tour de France: 7 wins

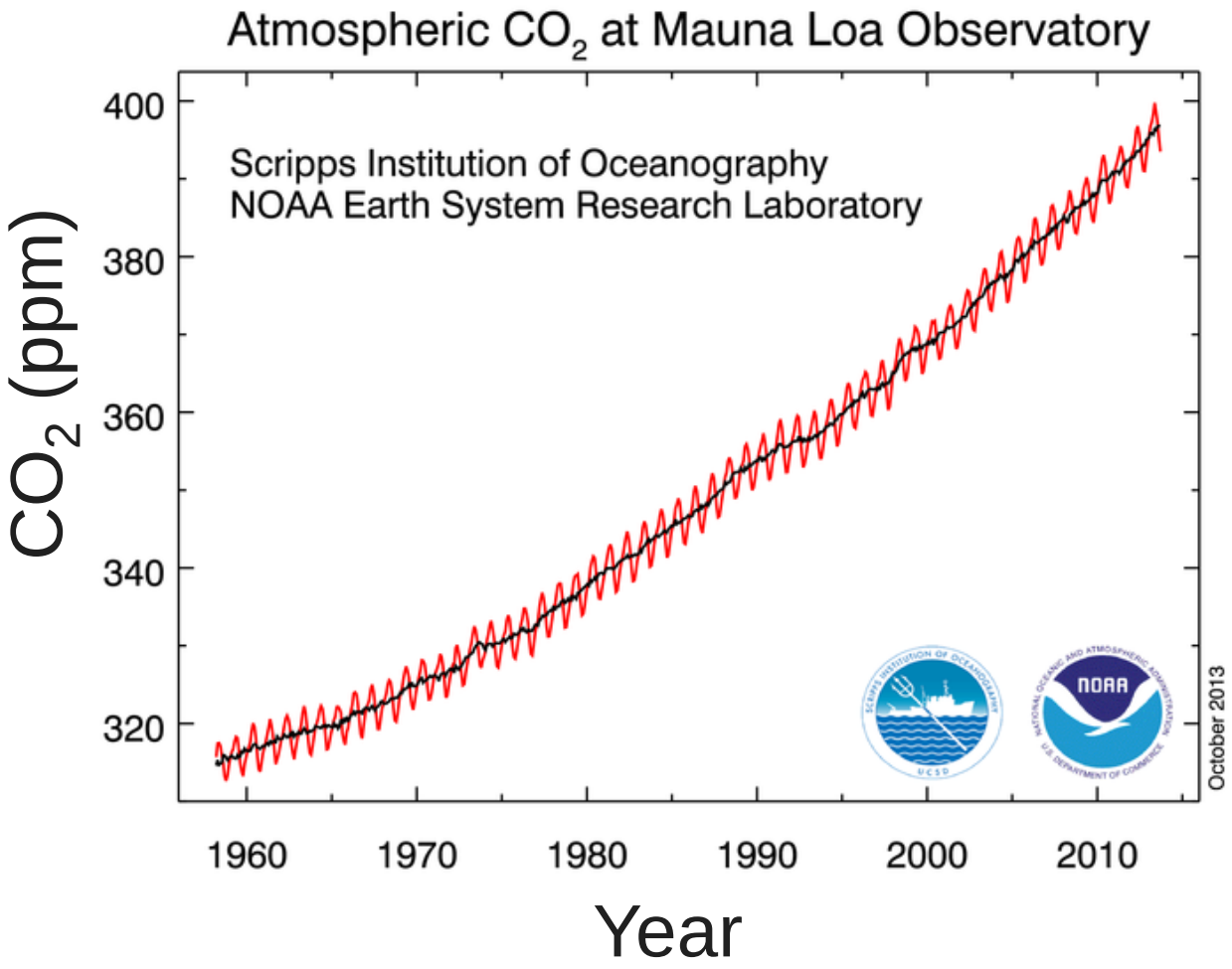
[1999–2005]

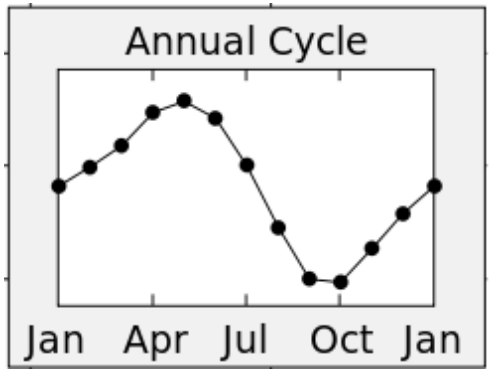
The Greenhouse Effect



Courtesy of Chip Fletcher

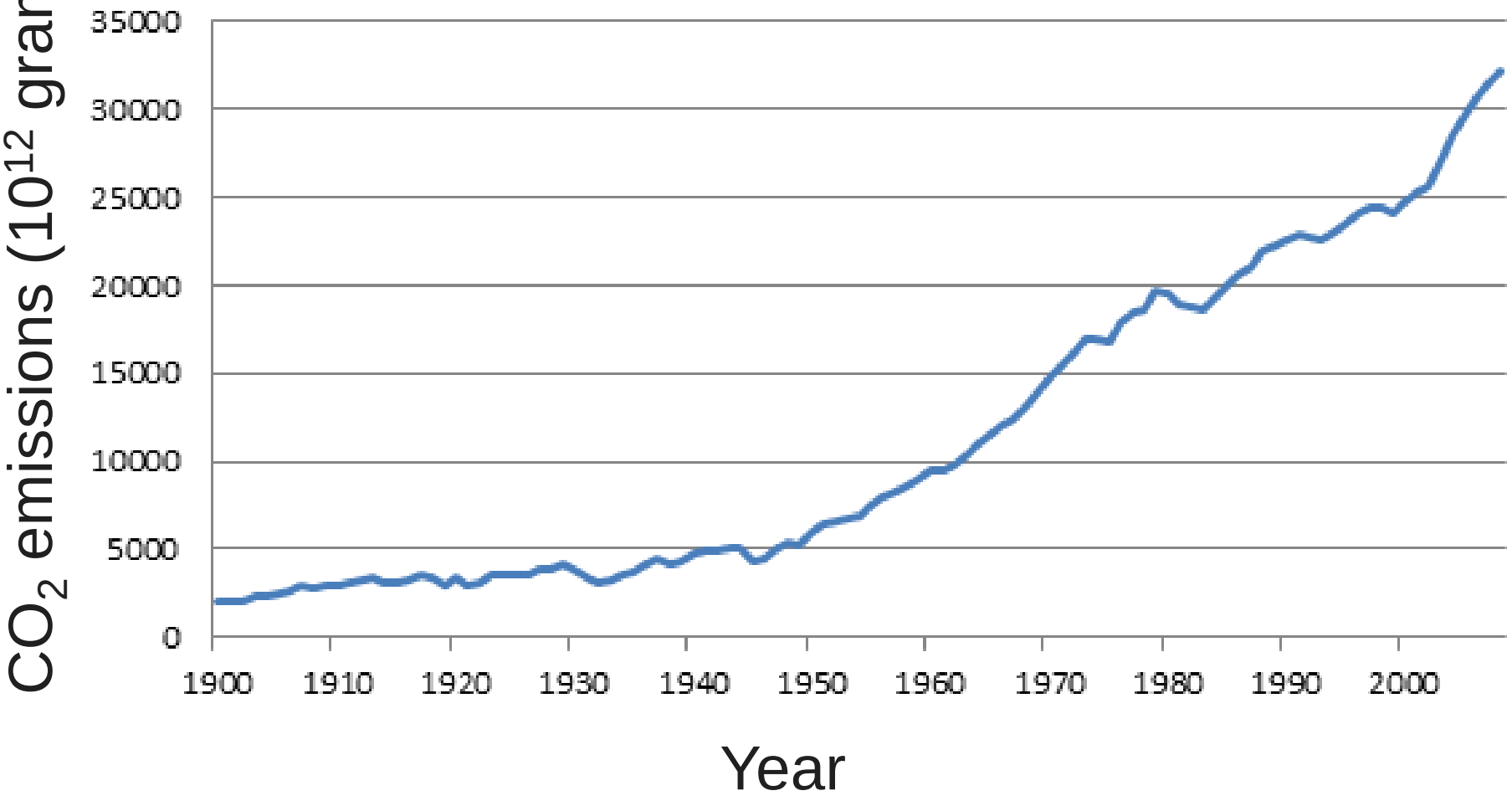
CO_2 vs. Time
(Since 1958, "Keeling Curve")





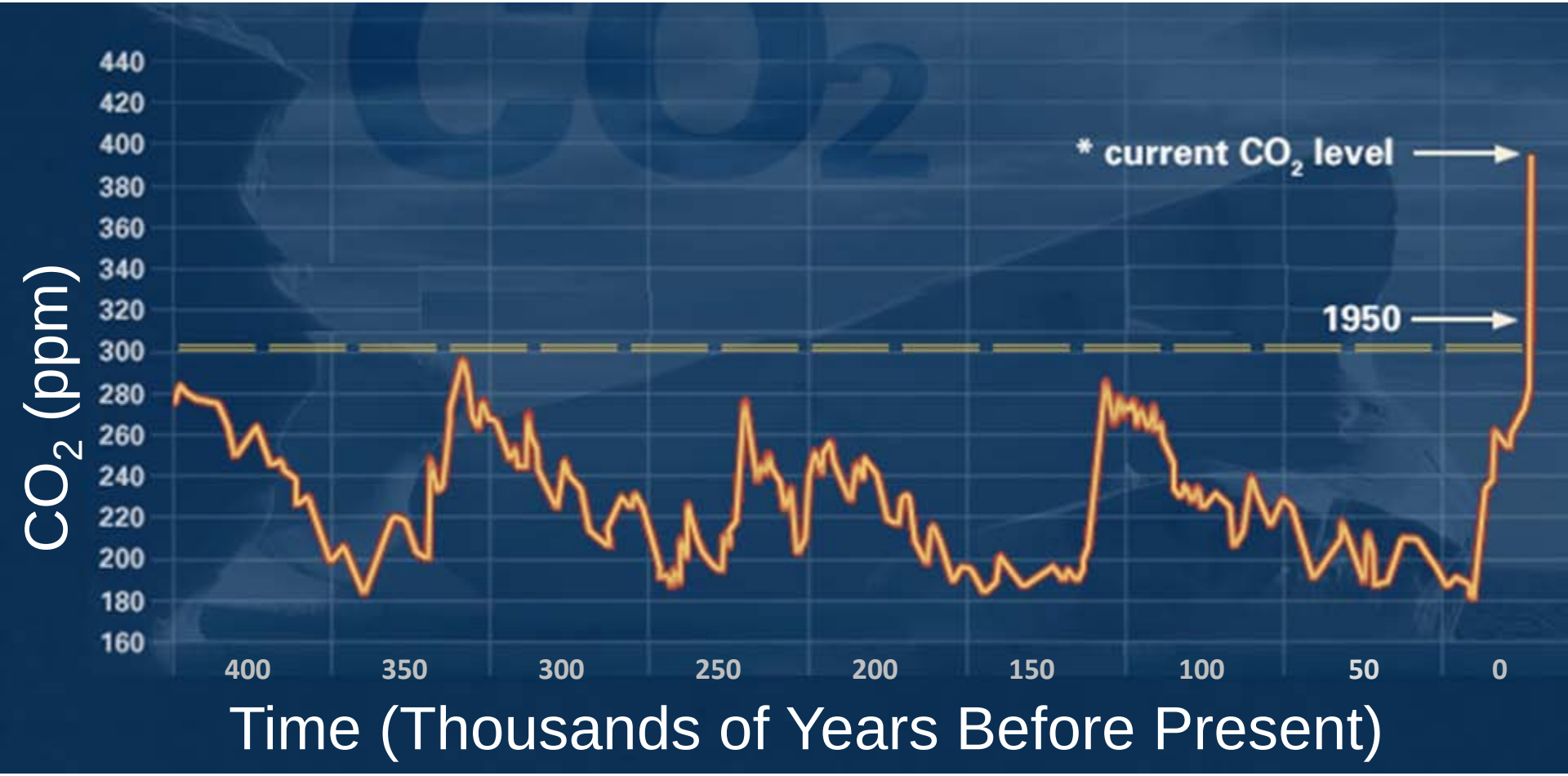
sciencedoing.blogspot.com

CO_2 vs. Time
(Since 1900)



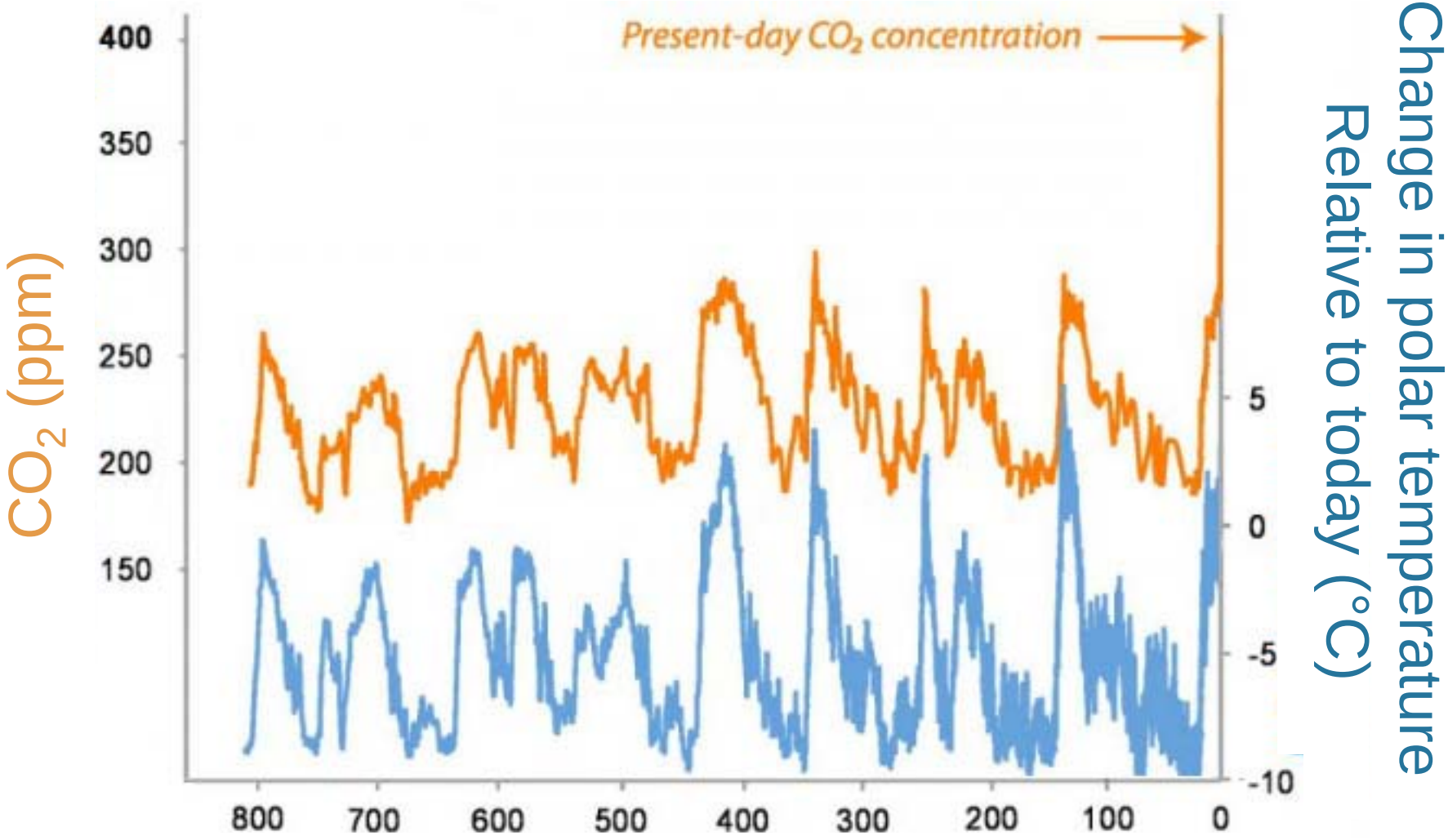
http://www.epa.gov/climatechange/ghgemissions/global.html

CO_2 vs. Time (last 400K years)



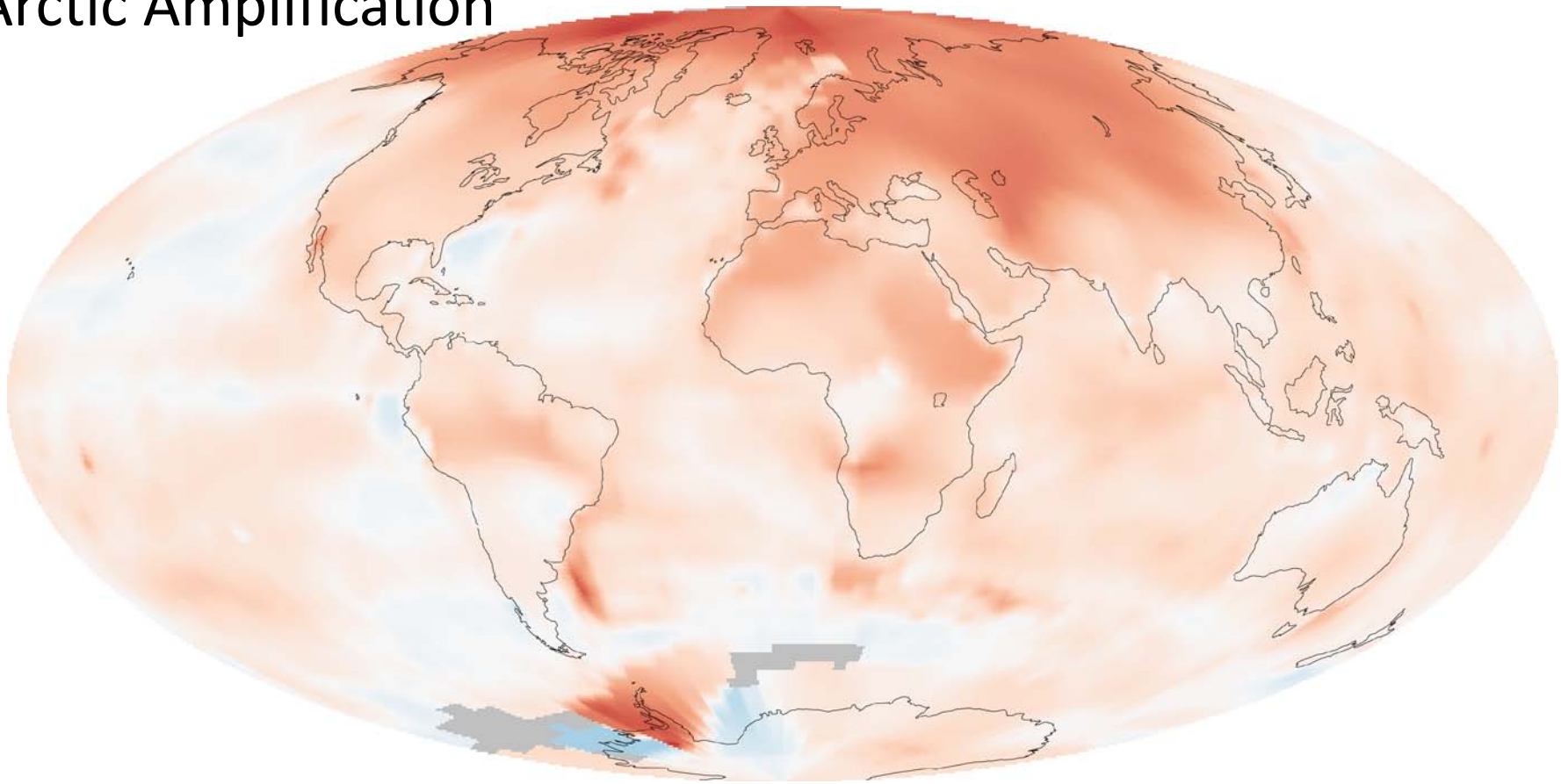
Climate.nasa.gov

CO_2 and Temperature vs. Time
(last 800K years)



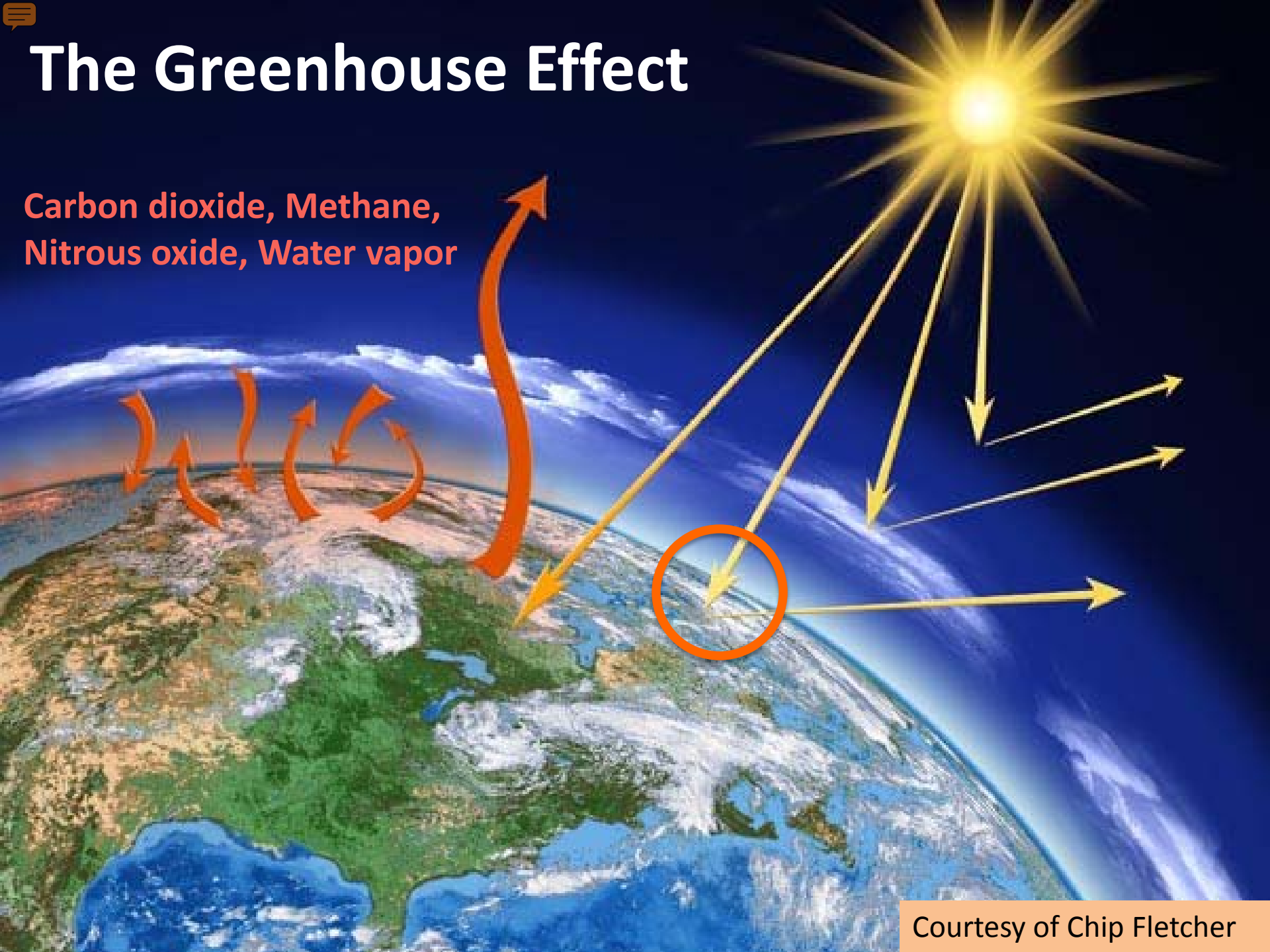
Global Temperature Anomalies (2000-2009 vs. 1951-1980)

"Arctic Amplification"



NASA /Robert Simmon, based on GISS data

The Greenhouse Effect



Courtesy of Chip Fletcher

So far we haven't looked at any predictions about future climate – we just looked at data already collected

We will look at models in a minute, but first……

Some Myths from Climate "~~Skeptics~~" Deniers

- Mauna Loa is a volcano (CO_2 record unreliable)
- It's the sun (not humans that causes global warming)
- It's not bad (warm periods are good for people)
- CO_2 lags temperature (so it can't cause warming)
- It's freaking cold! (so Earth can't be warming)
- Climate change is just a theory (no consensus)

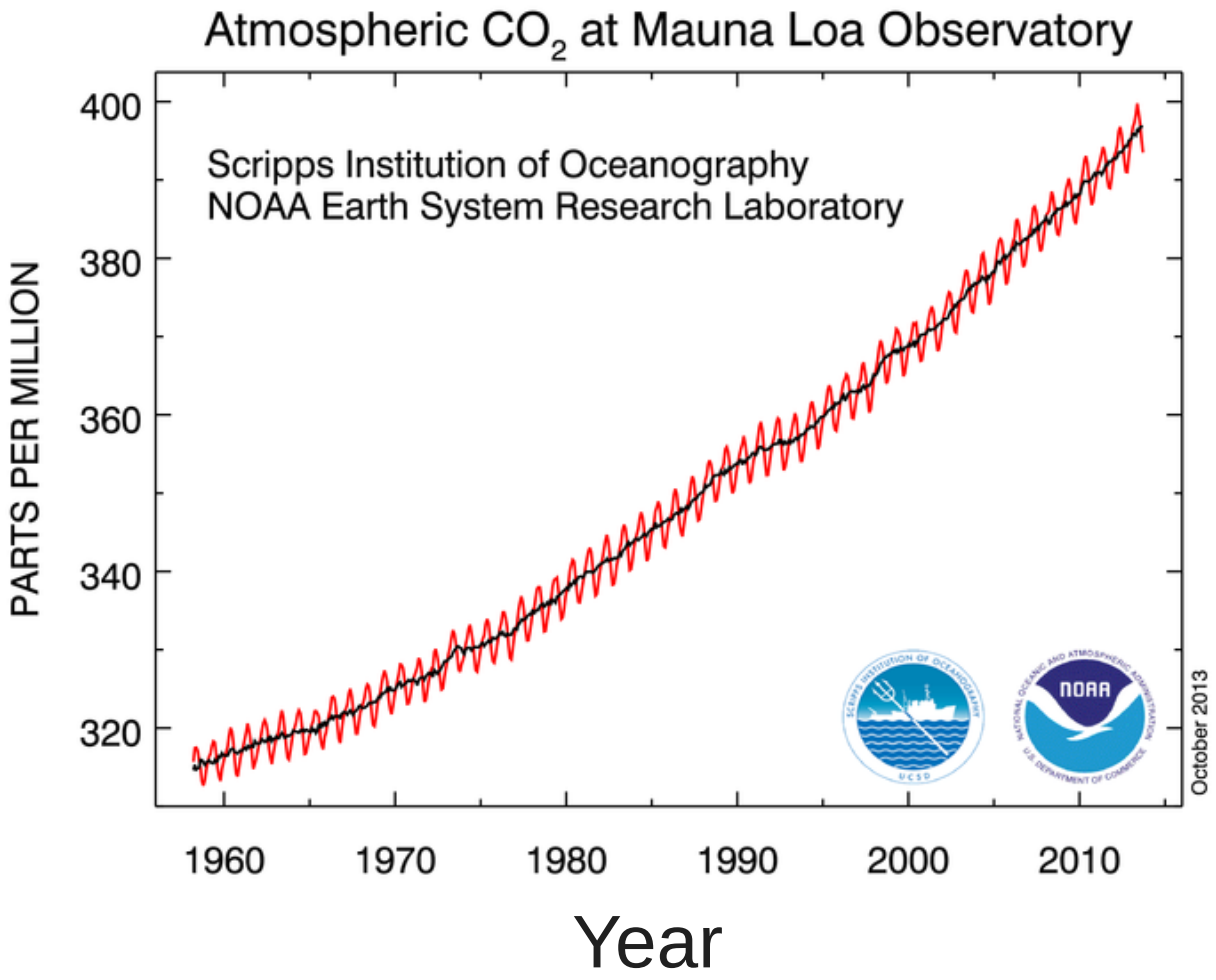
Etc.

Activity #1: Debunk the Myths

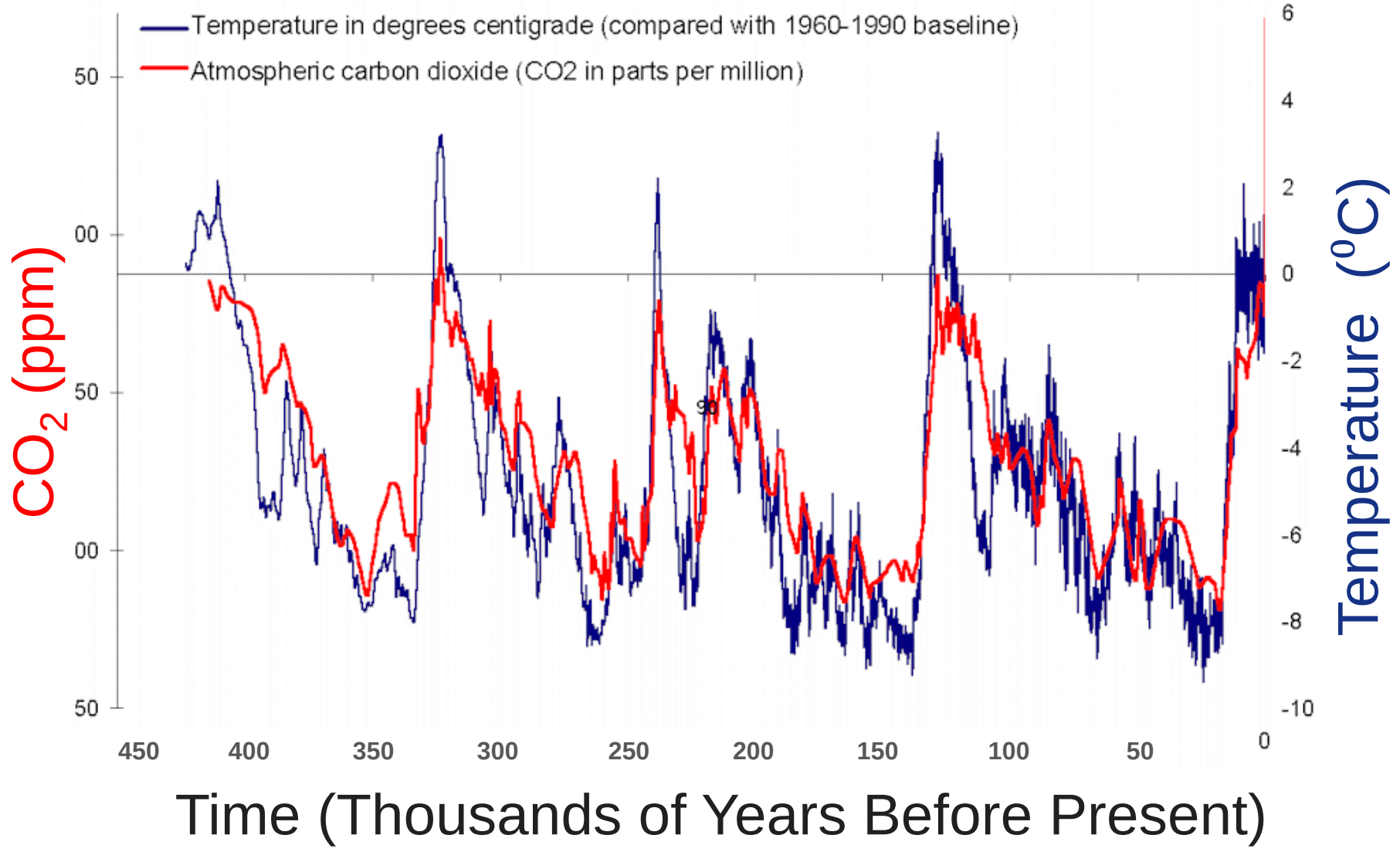
- Pick your favorite climate myth, and find out what the science says
- Go to www.skepticalscience.com (or use printouts in binder)
- Work in pairs/small groups

Does volcano affect CO_2 readings?

CO_2 (ppm)



Does CO_2 lag Temperature?



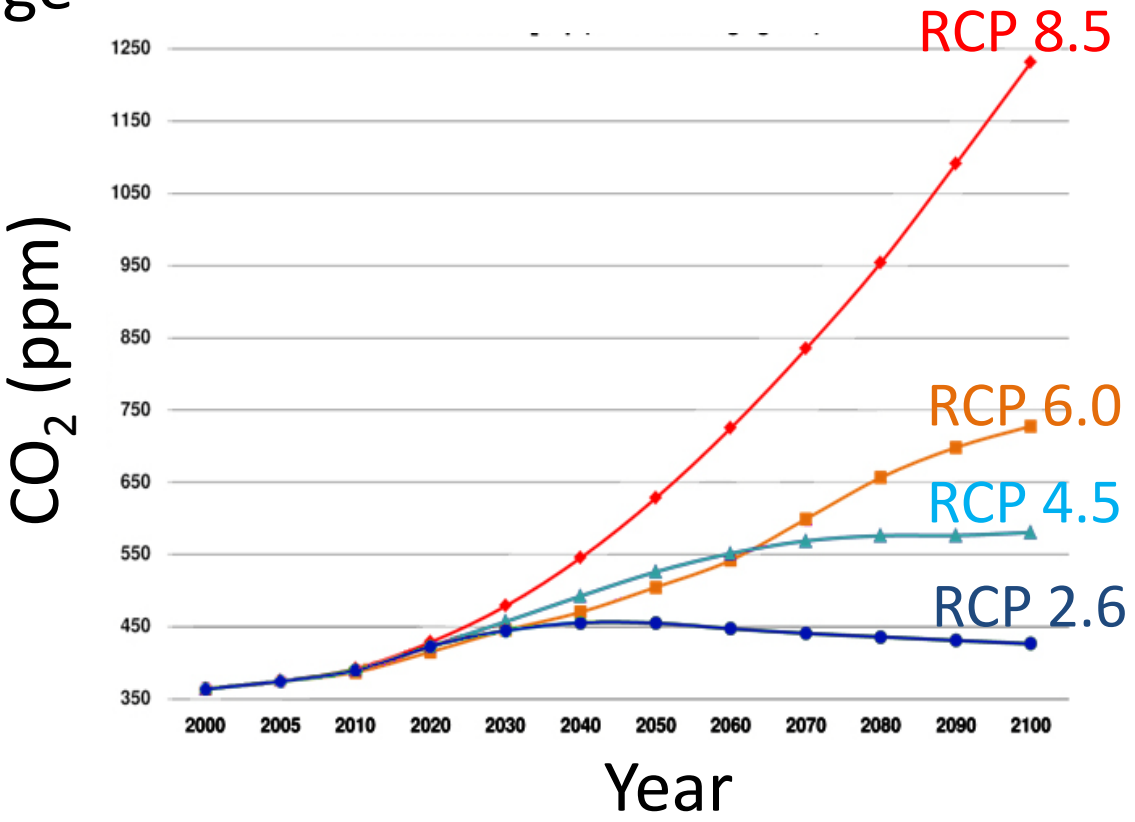
http://www.brighton73.freeserve.co.uk/gw/paleo/400000yearslarge.gif

Future Climate Predictions

Intergovernmental Panel on Climate Change (IPCC)

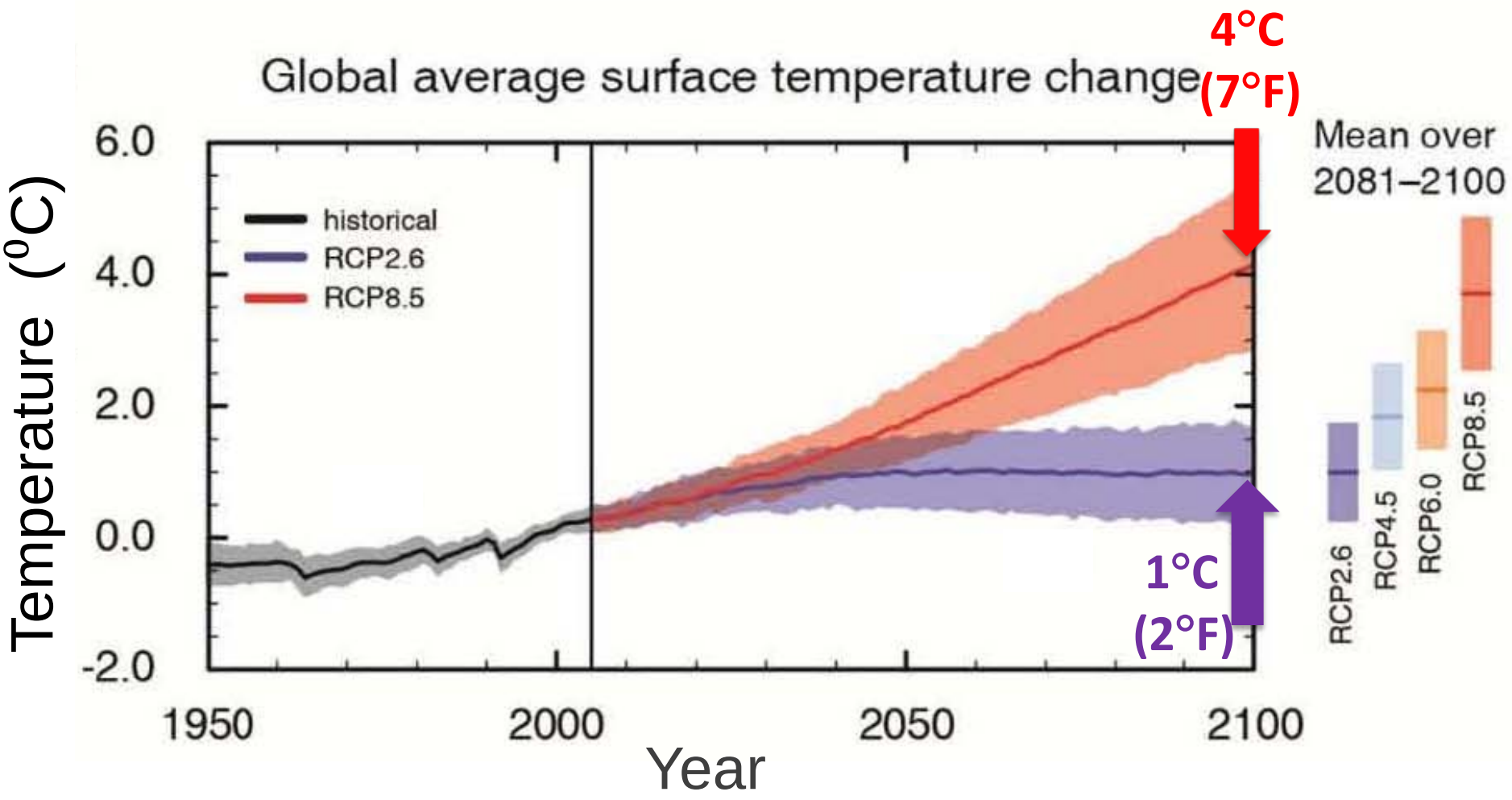
- Established 1988 by UN and WMO
- >2000 experts from 195 countries
- Assess climate change

"Representative Concentration Pathways" (RCP's)



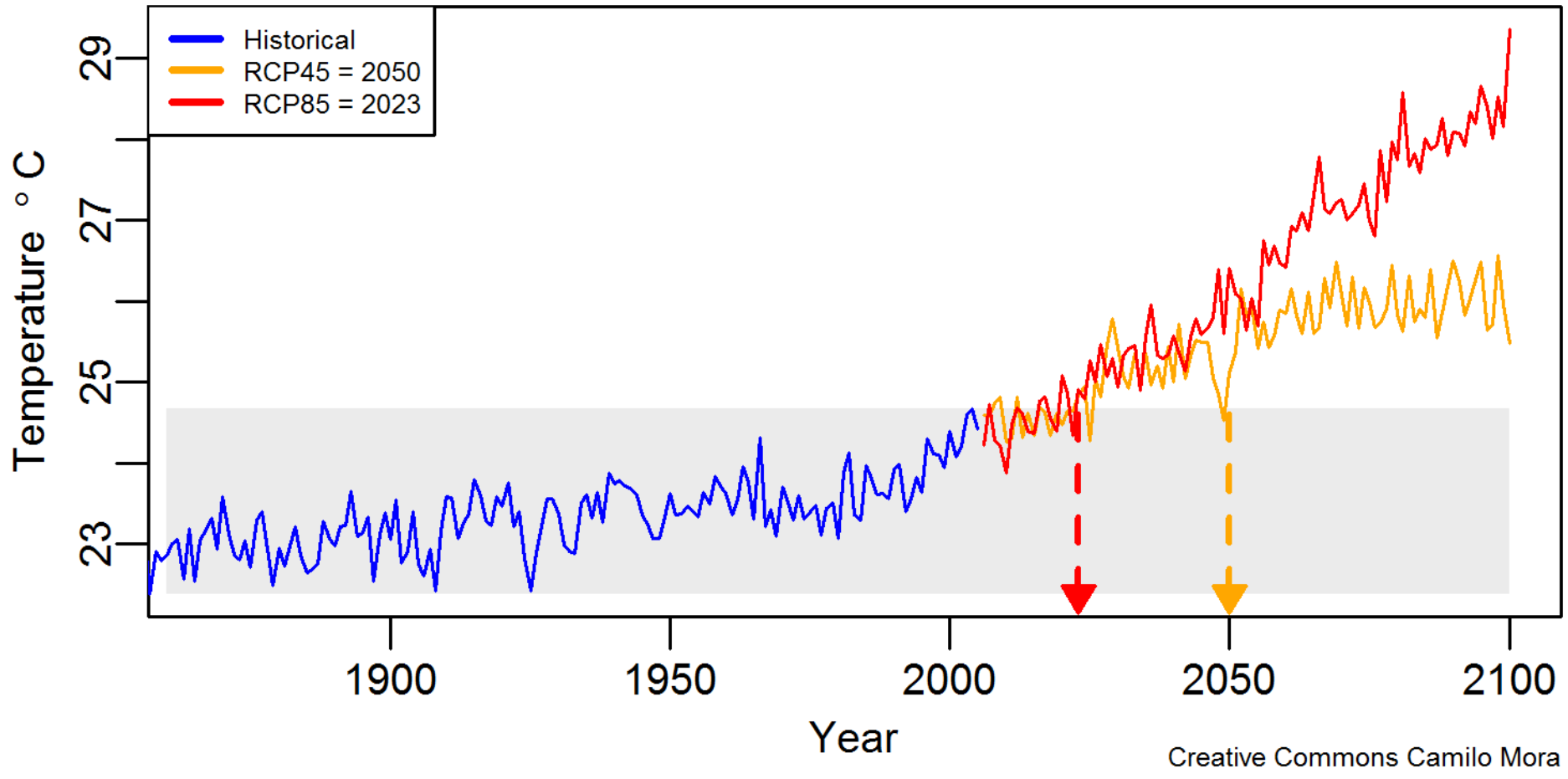
www.ipcc.ch

IPCC Predictions: Temperature



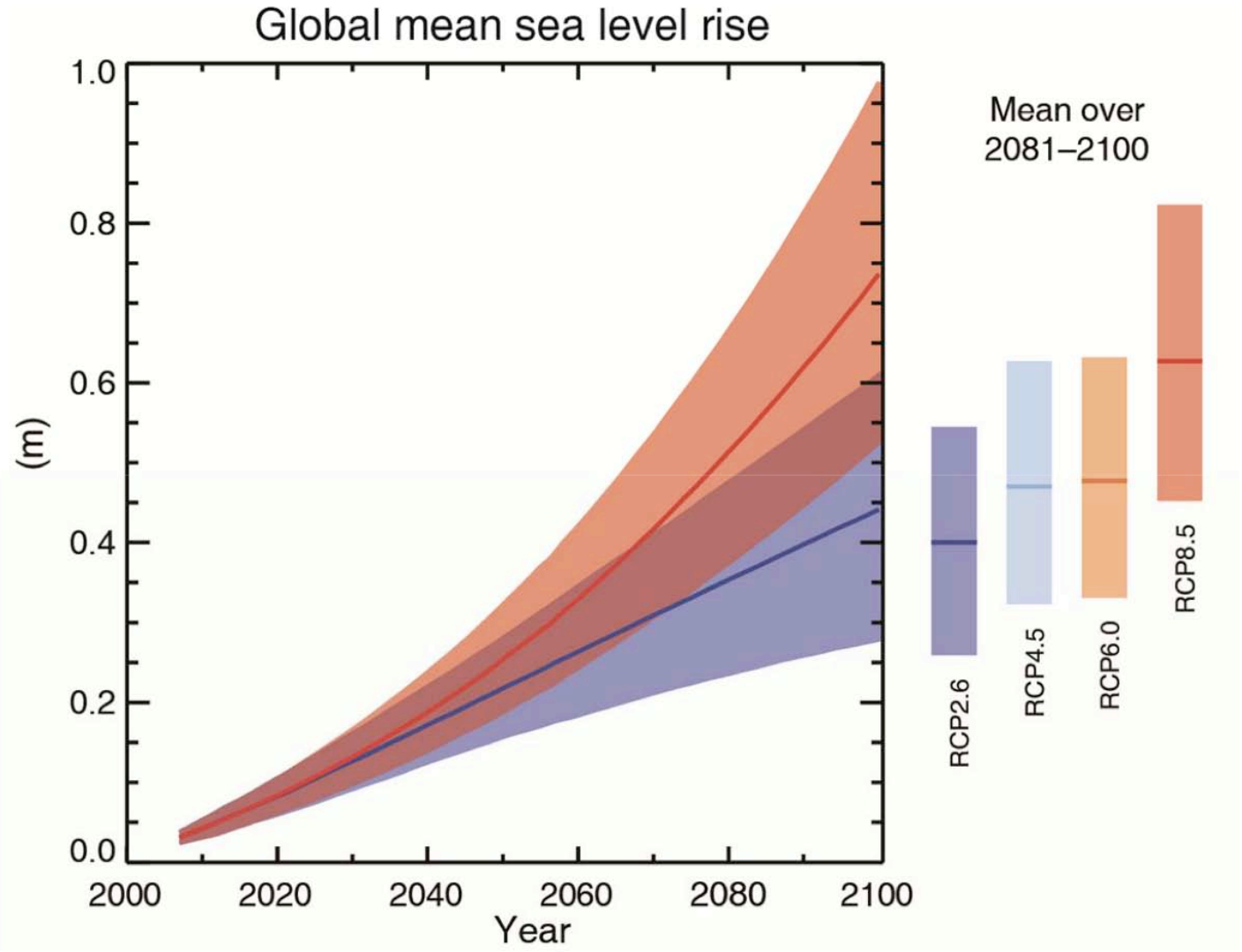
IPCC Fifth Assessment Report (2013) – Approved Summary for Policymakers (Fig SPM.7a)

When will climate exceed historical variability? *"Climate departure"*



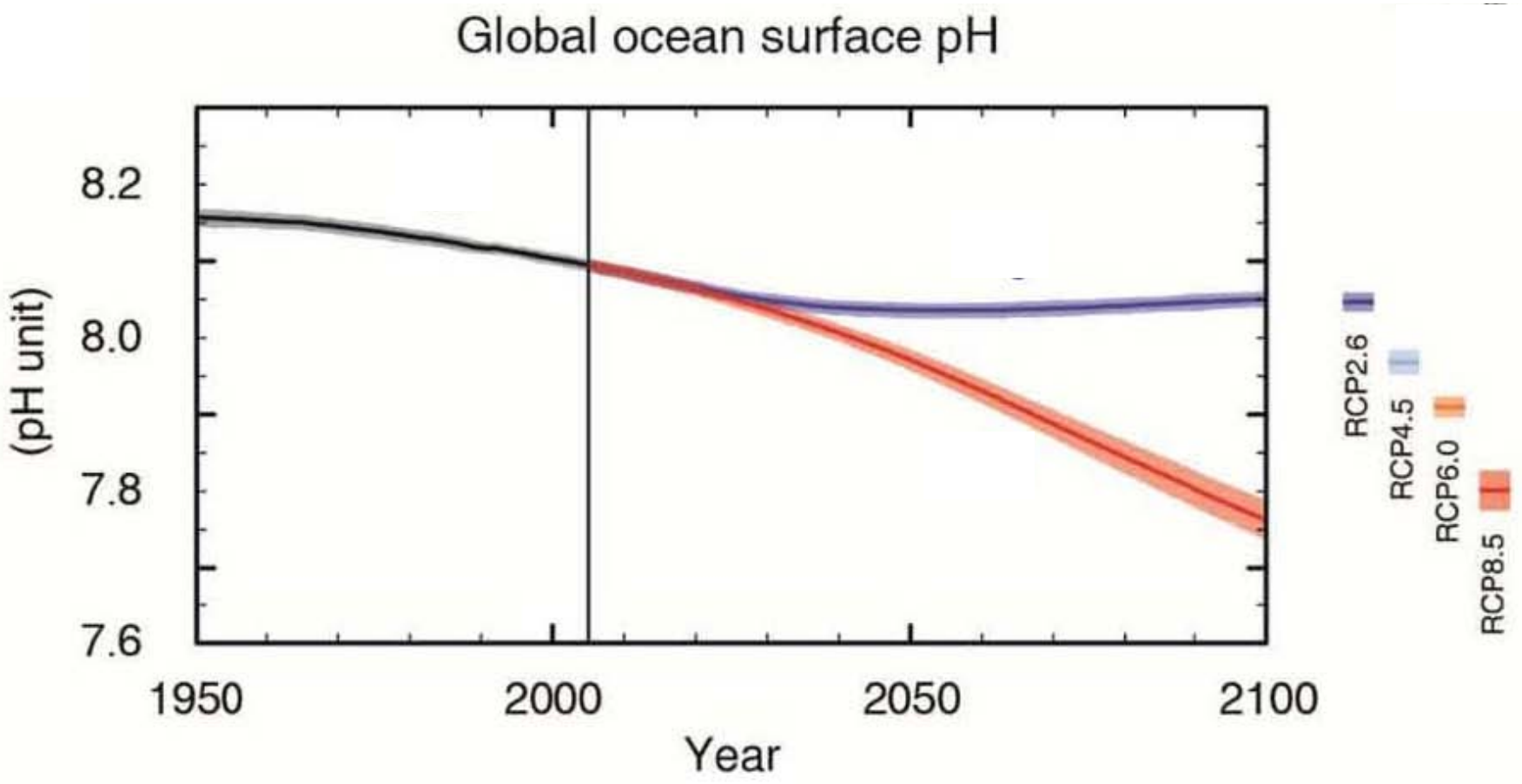
C Mora *et al. Nature* **502**, 183-187 (2013) doi:10.1038/nature12540

IPCC Predictions: Sea Level



IPCC Fifth Assessment Report (2013)

IPCC Predictions: pH



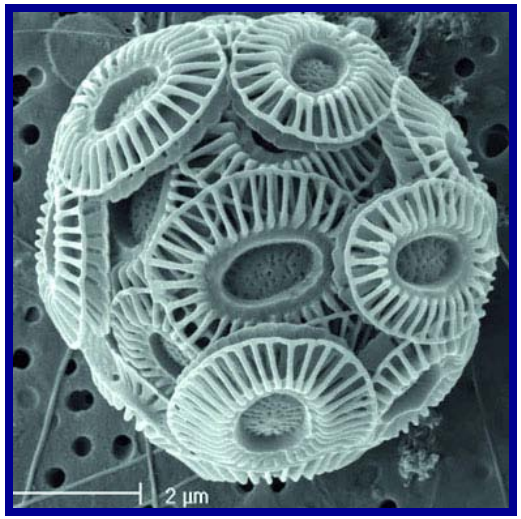
IPCC Fifth Assessment Report (2013) – Approved Summary for Policymakers (Fig SPM.7c)

Ocean Acidification

("the other CO_2 problem")

Corals

Calcareous plankton



$CO_2 + H_2O \longrightarrow H_2CO_3$

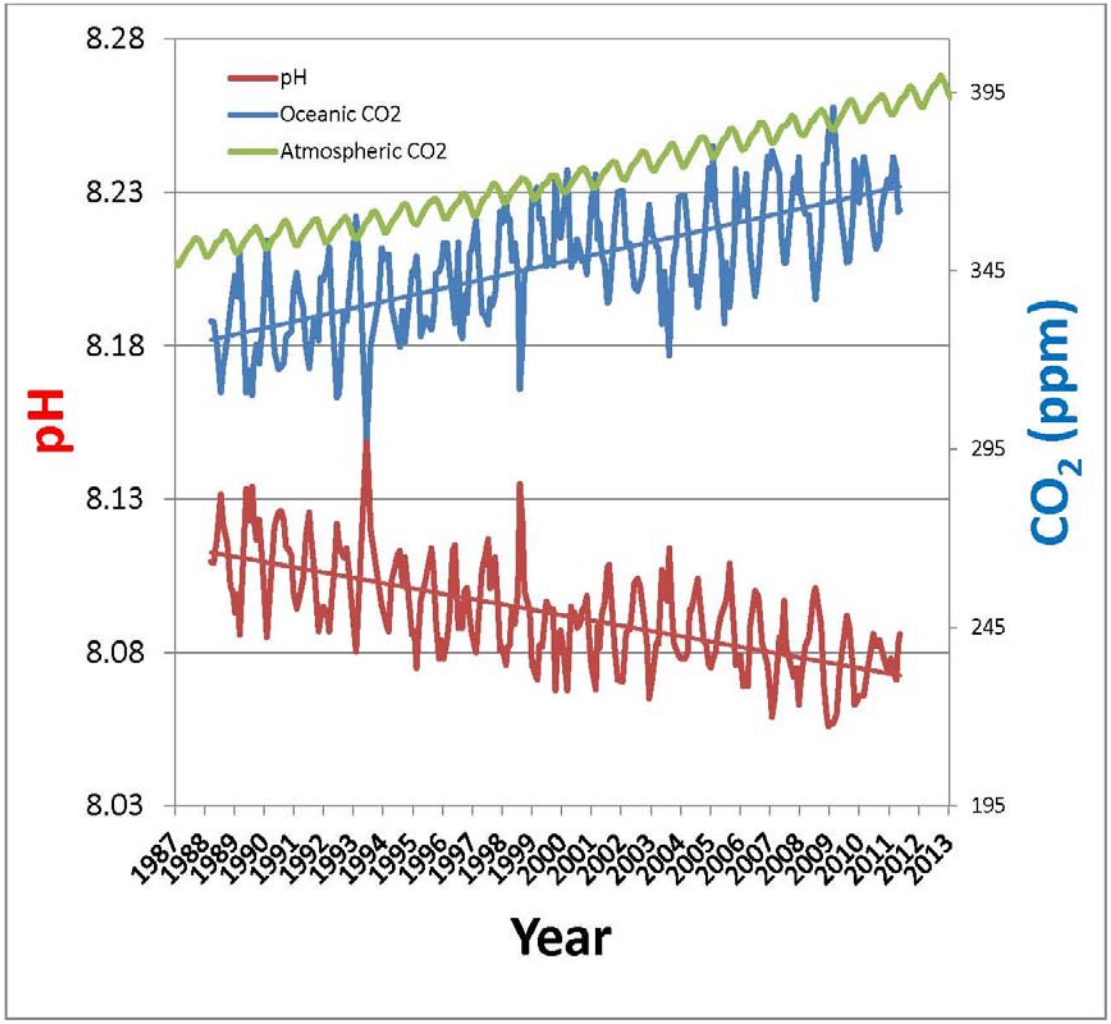
Carbonic acid decreases pH.

$CO_2 + CO_3^{2-} + H_2O \longrightarrow 2HCO_3^-$

Decreased carbonate concentration.

cmore.soest.hawaii.edu/education.htm

Activity #2: How has Ocean Chemistry changed in the past 25 years?



1) Form groups (one computer per group)

2) Download data: www.higp.hawaii.edu/~bruno/downloads/

3) Graph data using EXCEL (instructions on handout)

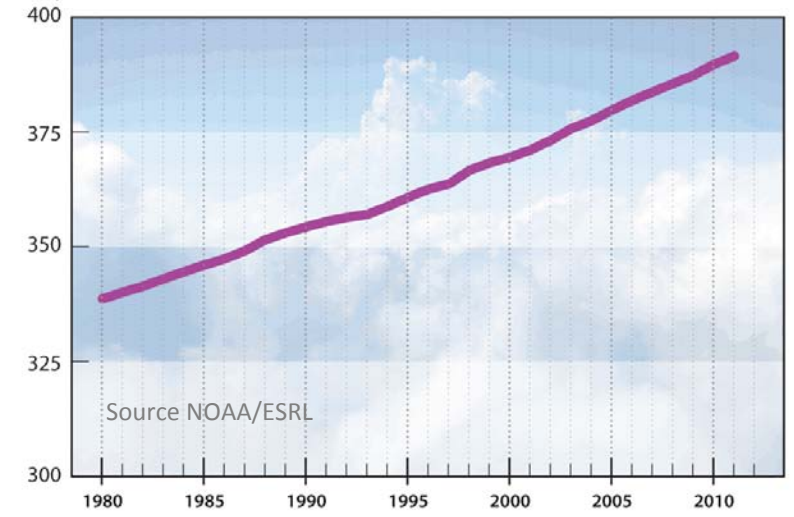
4) Interpret data by answering questions (please add your own)

Global Climate is Really Changing

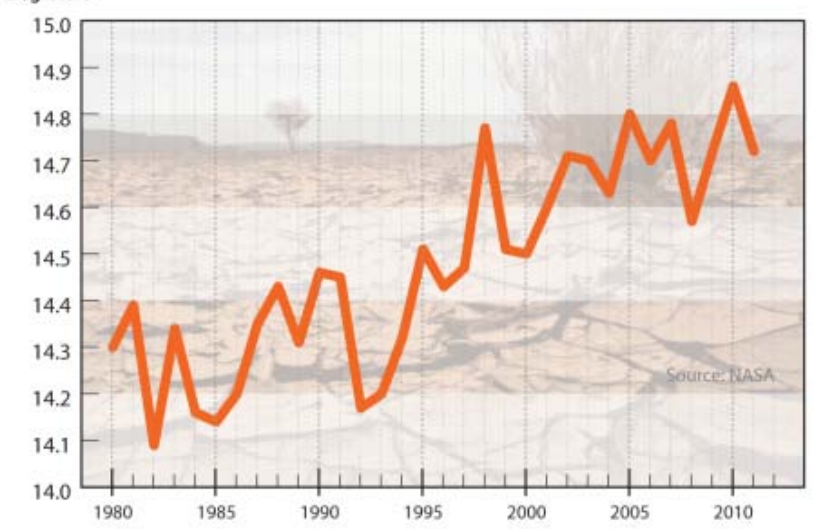
Climate Change Indicators

International Geosphere-Biosphere Programme

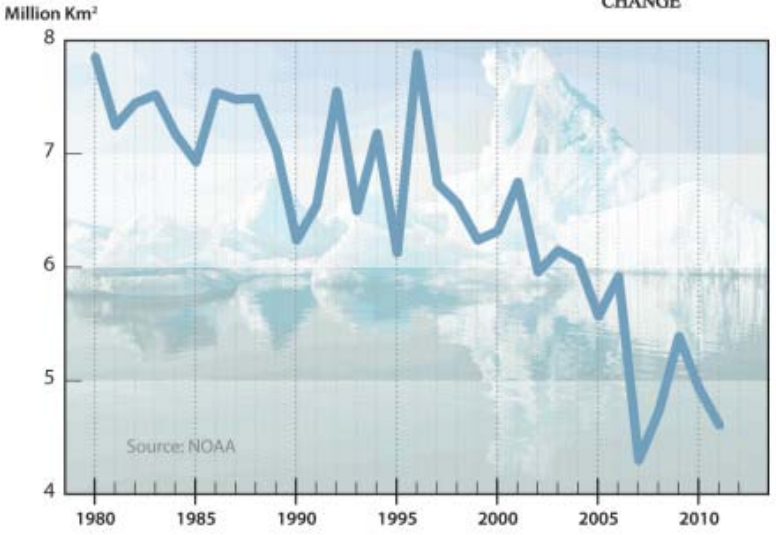
Atmospheric CO_2



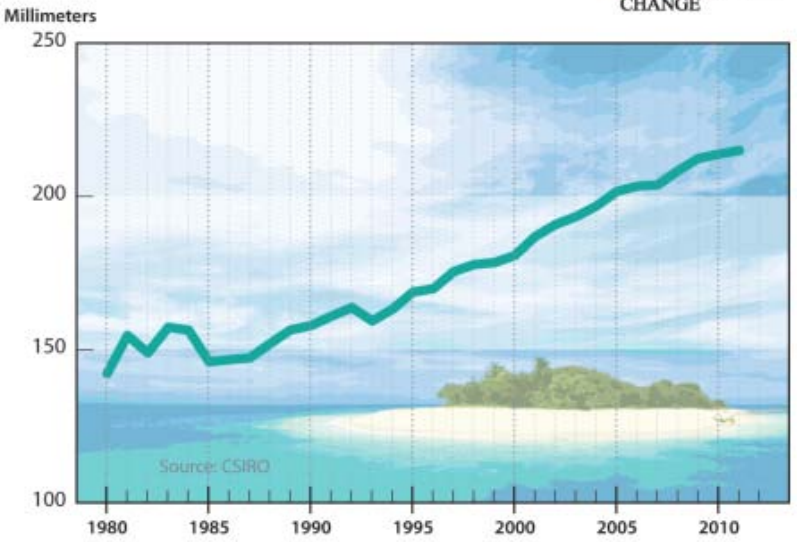
Global average land surface temperature



Arctic summer sea-ice minimum

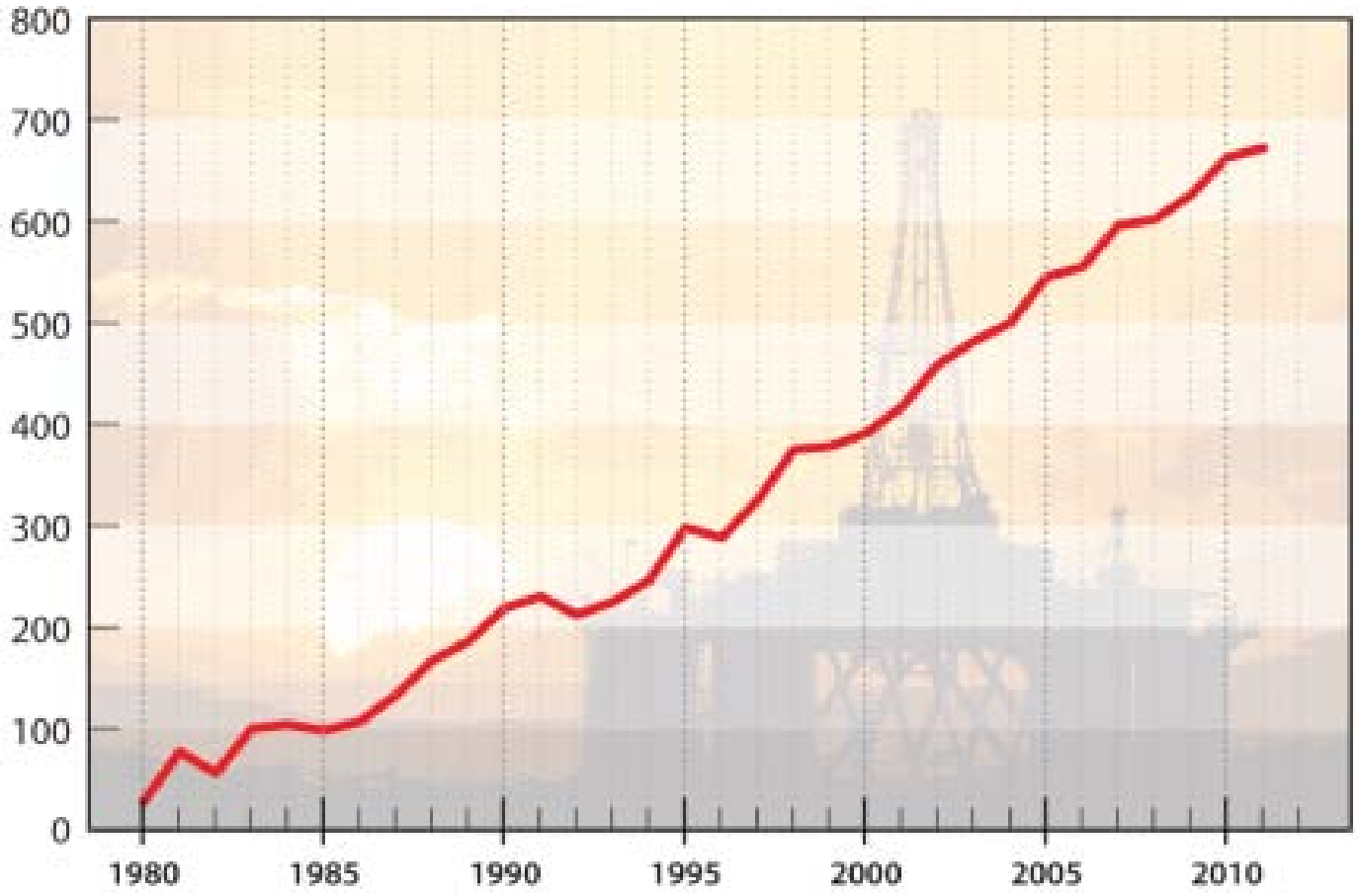


Global sea level



Climate Change Index - Cumulative

International Geosphere-Biosphere Programme



Next Generation Science Standards Disciplinary Core Ideas

Earth Systems Science

- ESS2.A Earth's Systems (Earth Materials and Systems)
- ESS2.D Earth's Systems (Weather & Climate)
- ESS3.B Earth & Human Activity (Natural Hazards)
- ESS3.C Earth & Human Activity (Human Impacts on ES)
- ESS3.D Earth & Human Activity (Global Climate Change)

Physical and Life Sciences

- PS1.B Matter & Its Interactions (Chemical Reactions)
- PS4.B Waves (Electromagnetic Radiation)
- LS4.C Biological Evolution: Unity & Diversity (Adaptation)

Suggested Resources

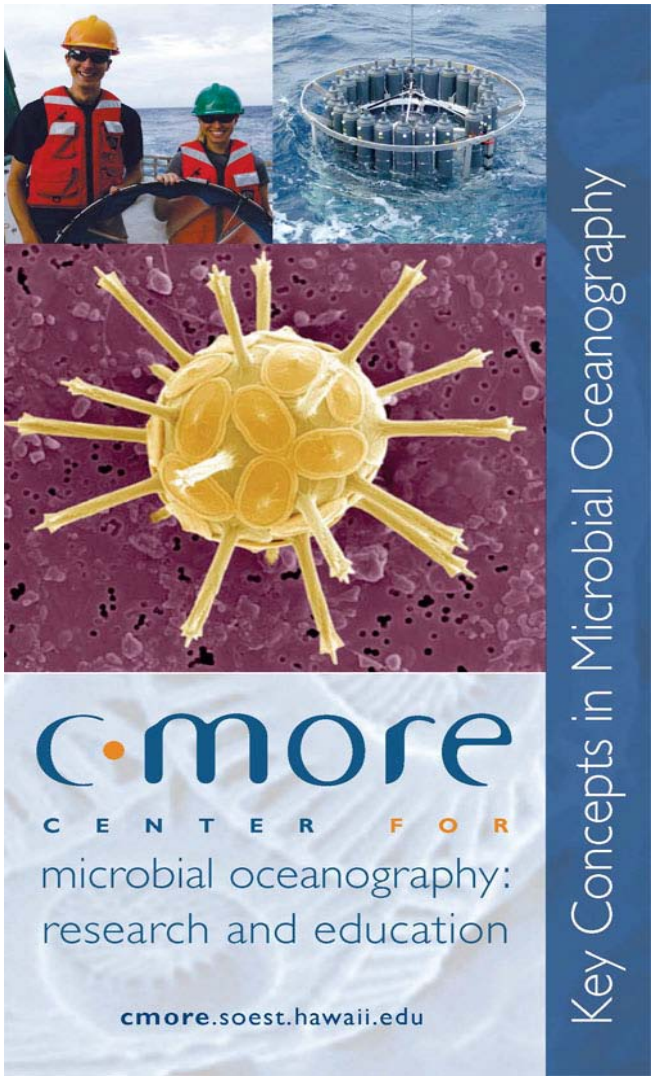
Textbooks

- Fletcher, Charles (2013) *Climate change: What the science tells us*. Wiley.
- Kitchen, David (2013) *Global climate change: Turning knowledge into action*. Pearson Education.

Websites

- IPCC http://www.ipcc.ch
- Skeptical Science http://www.skepticalscience.com/
- EPA http://www.epa.gov/climatechange/
- C-MORE cmore.soest.hawaii.edu/education.htm

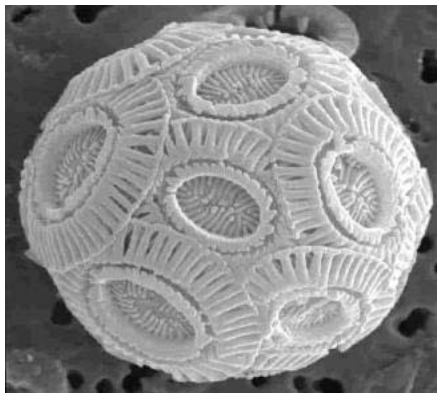
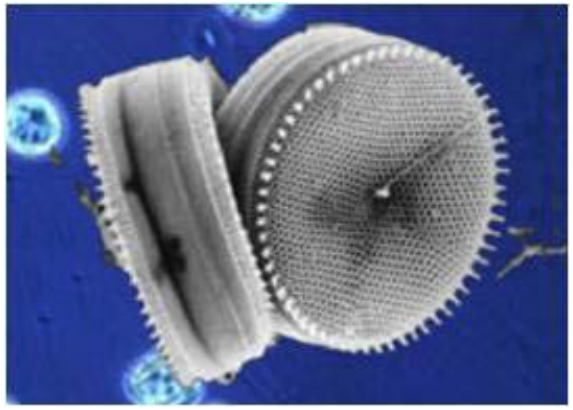
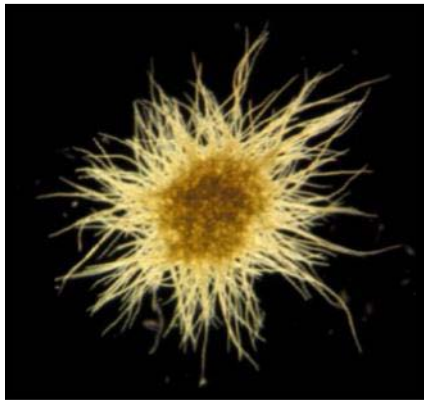
Bio extension: Marine Microbes:
We Can't Live Without Them



- Produce oxygen
- Help moderate the Earth's climate
- Our planet's main decomposers
- Base of food web

What Microbe Are You?

- Discover your microbe personality!
- In each pair of statements, choose the one that best describes you.

Images: http://microscope.mbl.edu

Note: Quiz available in different levels & languages.

Dichotomous Key (for teachers) in your binder.

cmore.soest.hawaii.edu/education.htm

Please let me know how your teaching goes!

barb@hawaii.edu